5-1-2018

# Effect of calcium concentration on calcite flotation from apatite using carbonic gas

Amanda Soares
*Centro de Tecnologia Mineral (CETEM), Brazil*, ematiolo@cetem.gov.br

Suzanne Ferreira de Mello
*Centro de Tecnologia Mineral (CETEM/MCTIC). Rio de Janeiro, Brazil.*

Rafael Teixeira Rodrigues
*Universidade Federal do Rio Grande do Sul (UFRGS). Rio Grande do Sul, Brazil*

# EFFECT OF CALCIUM CONCENTRATION ON CALCITE FLOTATION FROM APATITE USING CARBONIC GAS

The Santa Quitéria deposit

**Amanda de Freitas**
**Elves Matiolo**
**Rafael Rodrigues**

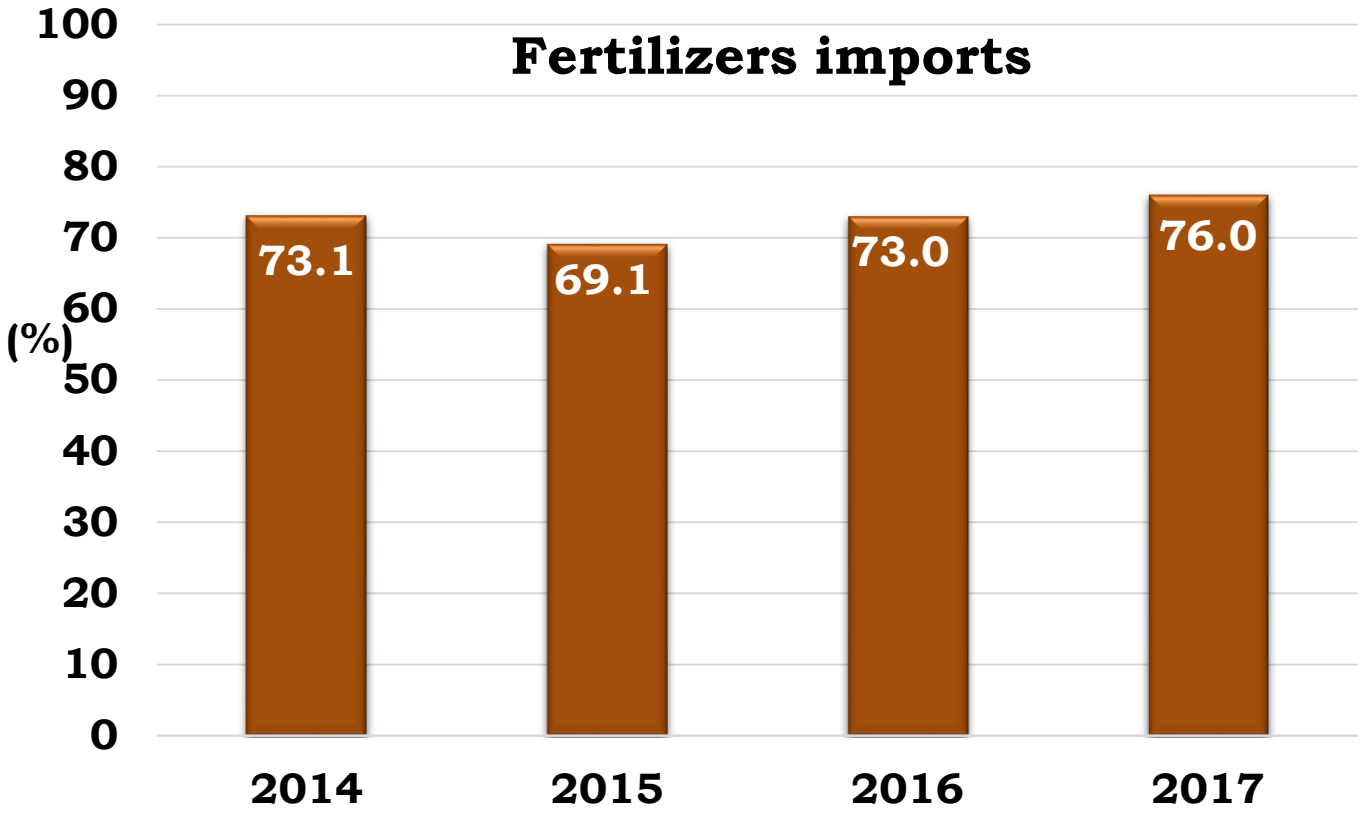
**Cape Town, May 2018**

# Brazil – Fertilizers

**National production** of fertilizers is **historically lower**

**77%** of fertilizer consumption is concentrated in 4 crops: **soybean, corn, sugarcane and coffee.**

**Grow** national demand

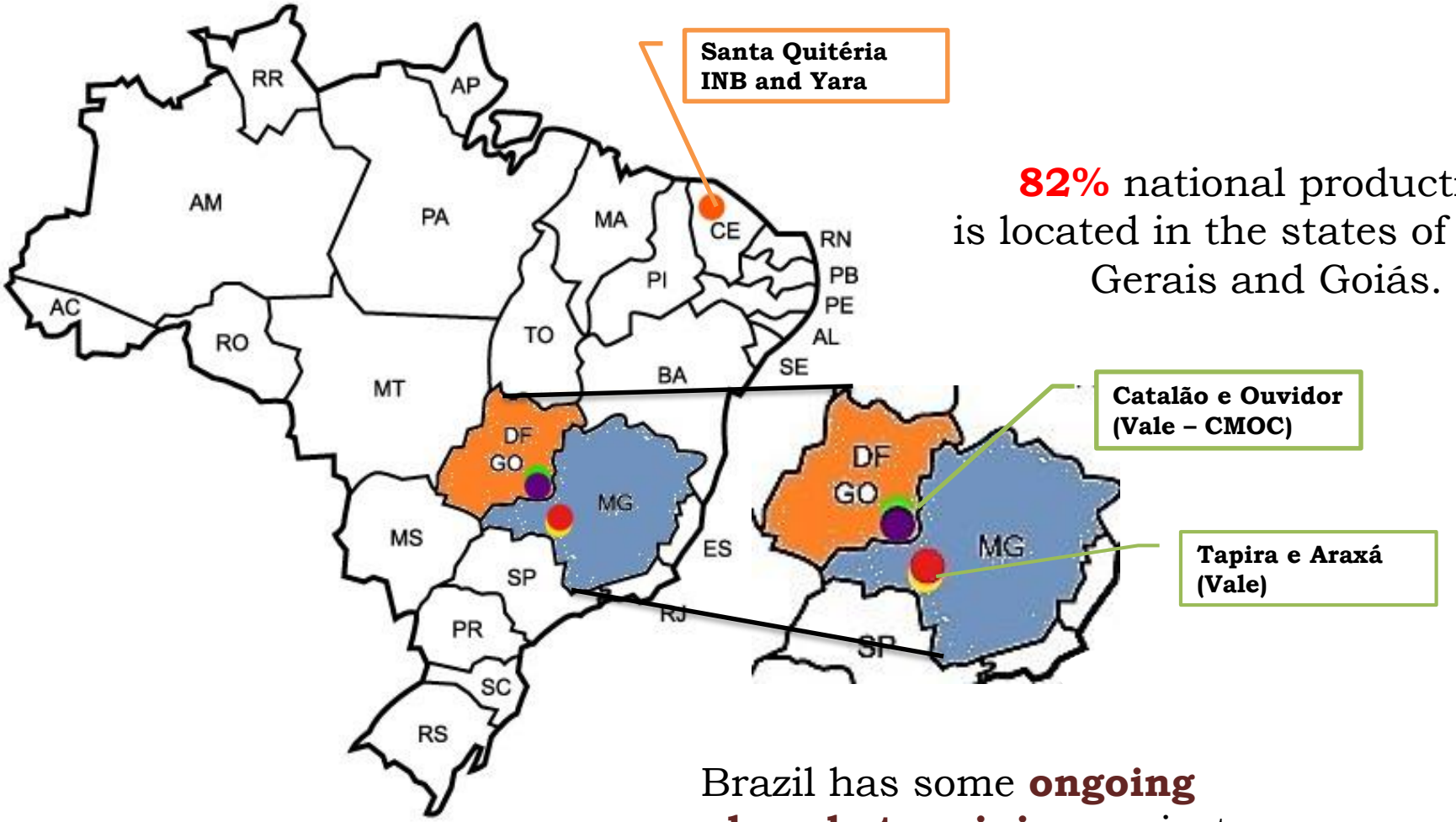



**Average 73%** was supplied by imports

# Brazil

**Around 95%** of the marketable phosphate are concentrated by the **flotation process**

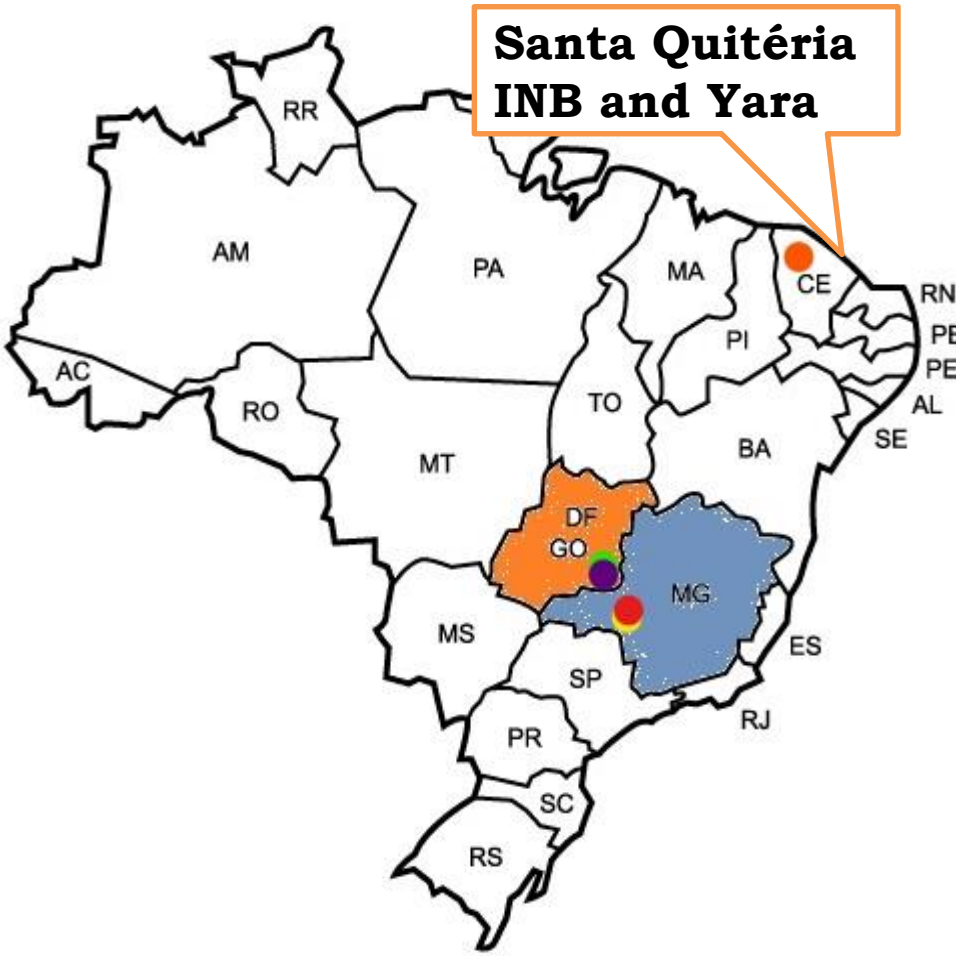
**13 mines** were responsible for the phosphate rock production in 2014.




**82%** national production is located in the states of Minas Gerais and Goiás.

Brazil has some **ongoing phosphate mining** projects

# The Santa Quitéria deposit




- **Discovered in 1975**

***Interest in uranium associated with apatite - Angra 3 nuclear power plant***

***Largest uranium deposit in the country***

- **80 millions tons (ore)**

***11% $P_2O_5$***

- **80.000 t $U_3O_8$**

- **Metamorphic Deposit**
- **Mineralogical composition**

***Apatite, calcite, quartz, graphite***

The separation of apatite from calcite by flotation is extremely difficult due to similarity in the surface physicochemical properties for both minerals

# Uranium - Phosphate ore (Santa Quitéria - CE)

## 1985

CDTN - Center for Development of Nuclear Technology

**Ore**

*Apatite – 36%*

*(15% $P_2O_5$)*

*Calcite – 24%*

*Silicates – 20%*

**Reagents**

*Fatty acid soap*

*Corn starch*

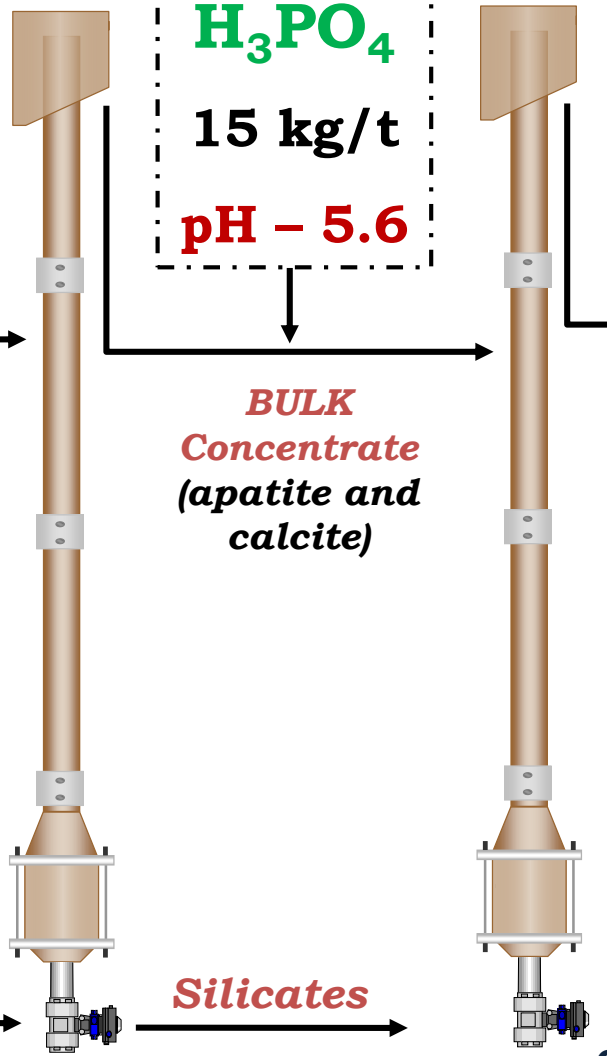
*Sodium silicate*

*pH – 10 (NaOH)*

$H_3PO_4$

15 kg/t

pH – 5.6



*BULK Concentrate (apatite and calcite)*

Calcite

*Silicates*

Air

Apatite concentrate

*32 – 34,5% $P_2O_5$*

*3 - 6% calcite*

**Although** this concept is **efficient** from the point of view of separation between apatite and carbonates;

→ **use of strong inorganic acids** (>15 kg/t) causes accumulation of ions in the process water, especially $Ca^{2+}$ and $PO_4^{2-}$;

→Leads to problems in **apatite recovery** and in the **environment.**

Effect of ionic species on the performance of apatite flotation

Mariana A. dos Santos, Ricardo C. Santana, Fabiano Capponi, Carlos H. Ataíde, Marcos A.S. Barrozo*

*Federal University of Uberlândia, School of Chemical Engineering, Bloco K – Santa Mônica, 38400-902 Uberlândia, MG, Brazil*

**Effect of ions on apatite flotation**

**INTERFERING IONS IN THE FLOTATION OF A PHOSPHATE ORE IN A BATCH COLUMN**

**R.C. GUIMARÃES[§] and A.E.C. PERES[†]**

INFLUÊNCIA DE ALGUNS ÍONS SOBRE A FLOTAÇÃO DE APATITA DO MINÉRIO DE ITATAIA

JOSÉ AURY DE AQUINO[1]

In **2017,** INB (Nuclear Industries of Brazil) :

- Experimental tests with the Santa Quiteria ore have been developed at pilot scale using the **flowsheet proposed by CDTN** and achieved the expected process results;

- However, **when the process water is recycled** containing high levels of calcium and phosphates ions, **it seriously affects the flotation performance;**

- **The Santa Quiteria is located at semi arid region that deal with supply water problems.**

# Mehrotra et al . (1986) - EUA

Known methods of reducing the carbonate mineral impurities involve flotation processes wherein a phosphate depressant is added to an aqueous slurry of phosphate rock prior to flotation. Known phosphate depressants include HF, sodium tripolyphosphate, sodium hexametaphosphate, sodium pyrophosphate, fluosilicic acid and orthophosphoric acid.

Problems associated with the above phosphate depressants include high costs and contamination of the water supply preventing reuse of the water in other flotation processes. The present invention remedies the above problems by providing a cheap and contamination-free phosphate rock depressant.

**United States Patent** [19]

**Mehrotra et al.**

[54] **BENEFICIATION OF HIGH CARBONATE PHOSPHATE ROCK**

[75] Inventors: **Vikram P. Mehrotra; Kallidaikurichi N. Sivaramakrishnan**, both of Terre Haute, Ind.

[11] **Patent Number: 4,568,454**

[45] **Date of Patent: Feb. 4, 1986**

# Rezende et al . (2012) and Takata et al. (2006) - BRAZIL

**United States**
**Patent Application Publication**
**Eduardo De Rezende et al.**

**PROCESS FOR OBTAINING APATITE CONCENTRATES BY FLOTATION**

Inventors: **Sebastião Eduardo De Rezende**, Araxa - MG (BR); **Josiane Silvia Martins**, Araxa - MG (BR); **Elves Matiolo**, Araxa - MG (BR); **Lauro Akira Takata**, Araxa - MG (BR)

**The Araxá Mine**

(11) (21) **PI 0504210-0 A**

(22) Data de Depósito: 29/09/2005
(43) Data de Publicação: **14/02/2006**
**(RPI 1832)**

(54) Título: **PROCESSO PARA OBTENÇÃO DE CONCENTRADOS DE APATITA**

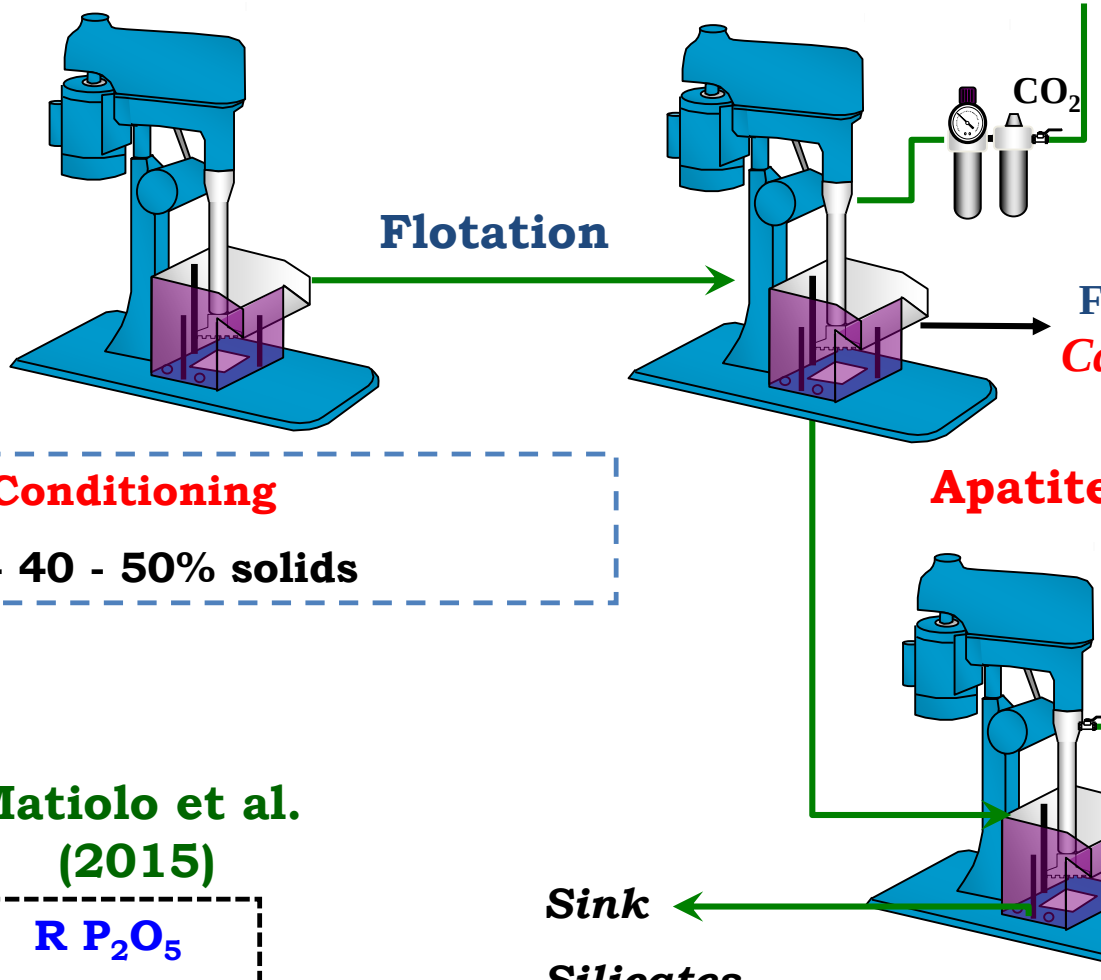
(71) Depositante(s): Bunge Fertilizantes S/A (BR/SP)

(72) Inventor(es): Lauro Akira Takata, Nelson Takessi Shimabukuro

(74) Procurador: M C Araújo Consultoria em Prop Indl Ltda

**The Catalão Mine**

# Carbonate phosphate ore from Santa Quitéria - CETEM




Matiolo et al. (2015)

R $P_2O_5$ 77%

33% $P_2O_5$

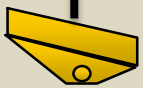
This work seeks to evaluate the effect of calcium ions on calcite flotation from apatite using carbonic gas in the sample from the Santa Quiteria deposit.

# EXPERIMENTAL

# Ore sample

Primary Crushing

Crushing < 3.36mm

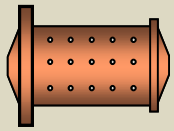


Screening

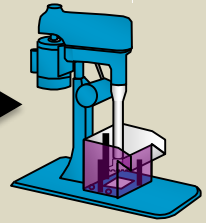
> 106um

73%

Coarse Fraction



Grinding



Calcite flotation

<10um

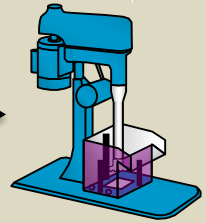
Slimes 7%

>10um <106um

<106um

Fines Fraction

20%



Calcite flotation

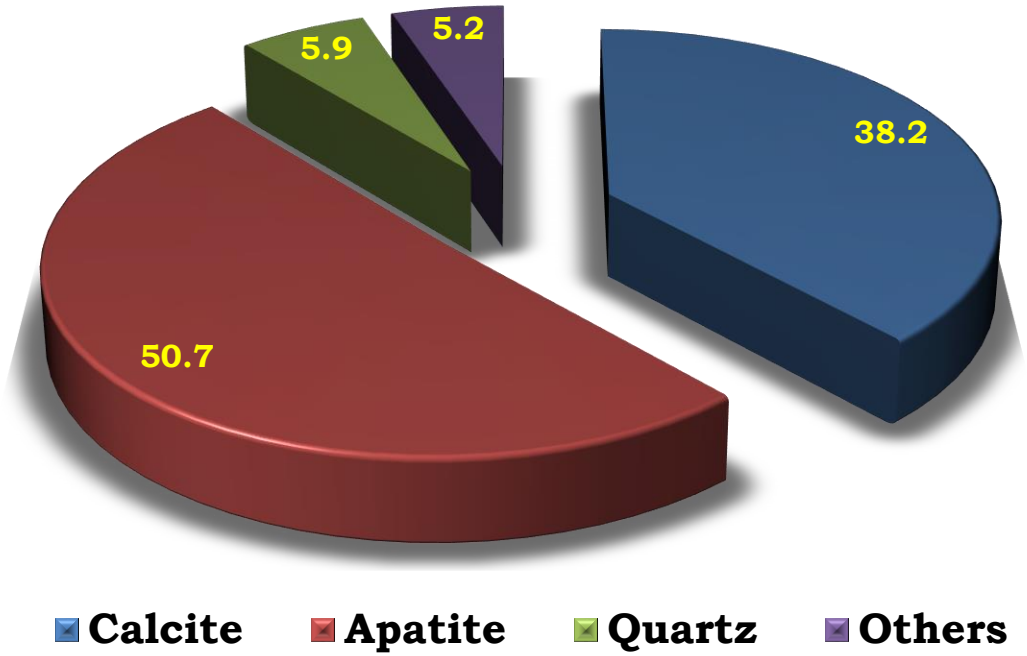
*Screening*

*Grinding*

*Calcite Flotation*

# Chemical and mineralogical characterization

| $CaO/P_2O_5$ | Grade (%) | | | | | | |
|---|---|---|---|---|---|---|---|
| | $P_2O_5$ | CaO | $Fe_2O_3$ | $SiO_2$ | MgO | $Al_2O_3$ | $TiO_2$ |
| 2.3 | 20.3 | 47.7 | 1.9 | 7.1 | 0.5 | 1.9 | 0.1 |

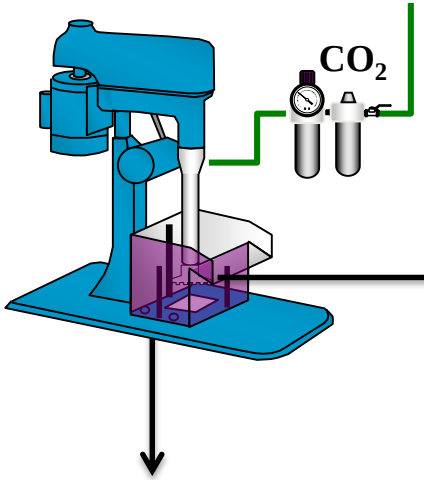


- **Calcite Flotation**: *Denver* D12 model; bench scale;
  - All the tests maintained the same process conditions .

**Conditioning**

- Collector
- **Coconut soap 500g/t**
- **5 minutes**
- pH natural= **8**
- **800 rpm**
- **50% solids**

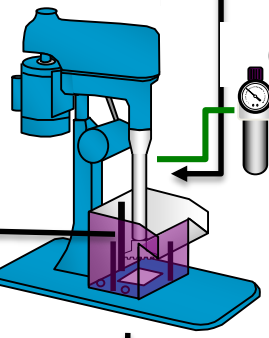
**Rougher**




- $Q_{CO2}$: **2L/min and 3L/min**;
- pH= **5.8**

***Float Calcite concentrate***

**Cleaner**




- $Q_{CO2}$: **2L/min**

- Flotation: **35% solids**
- Rougher: **10 minutes**
- Cleaner: **6 minutes**

**Sink fraction Rougher**

***Final Calcite Concentrate***

**Sink fraction Cleaner**

1. **Effect of the addition of calcium concentration [$Ca^{2+}$].**

2. **Effect of recirculating process water in calcite flotation.**

**The flotation performance was assessed in terms $P_2O_5$ content and $P_2O_5$ losses, the ratio $CaO/P_2O_5$ (RCP) and the mineralogical characterization.**

# Evaluate the effect of different calcium ions concentrations

- **Addition of Ca2+ ions in the process water for each desired concentration :**
  -> was performed through the solubilization of **$Ca(OH)_2$**.

**Calcite Flotation**

**Water with $Ca^{2+}$ ion concentration desired**


**Filtration**

**XRF and XRD analysis**


**Water collected**

**Atomic Absorption Spectrometry (AA)**
**$Ca^{2+}$ ion concentration analyzed**

**1st Standard test $Ca^{2+}$ (6mg/L)**
**2nd $Ca^{2+}$= 95 mg/L**
**3rd $Ca^{2+}$= 246 mg/L**
**4th $Ca^{2+}$= 419 mg/L**
**5th $Ca^{2+}$= 670 mg/L**

# Effect of recirculating process water in calcite flotation

Calcite Flotation

Filtration

Tap water supplied by CETEM.


XRF and XRD analysis


Recirculating process water

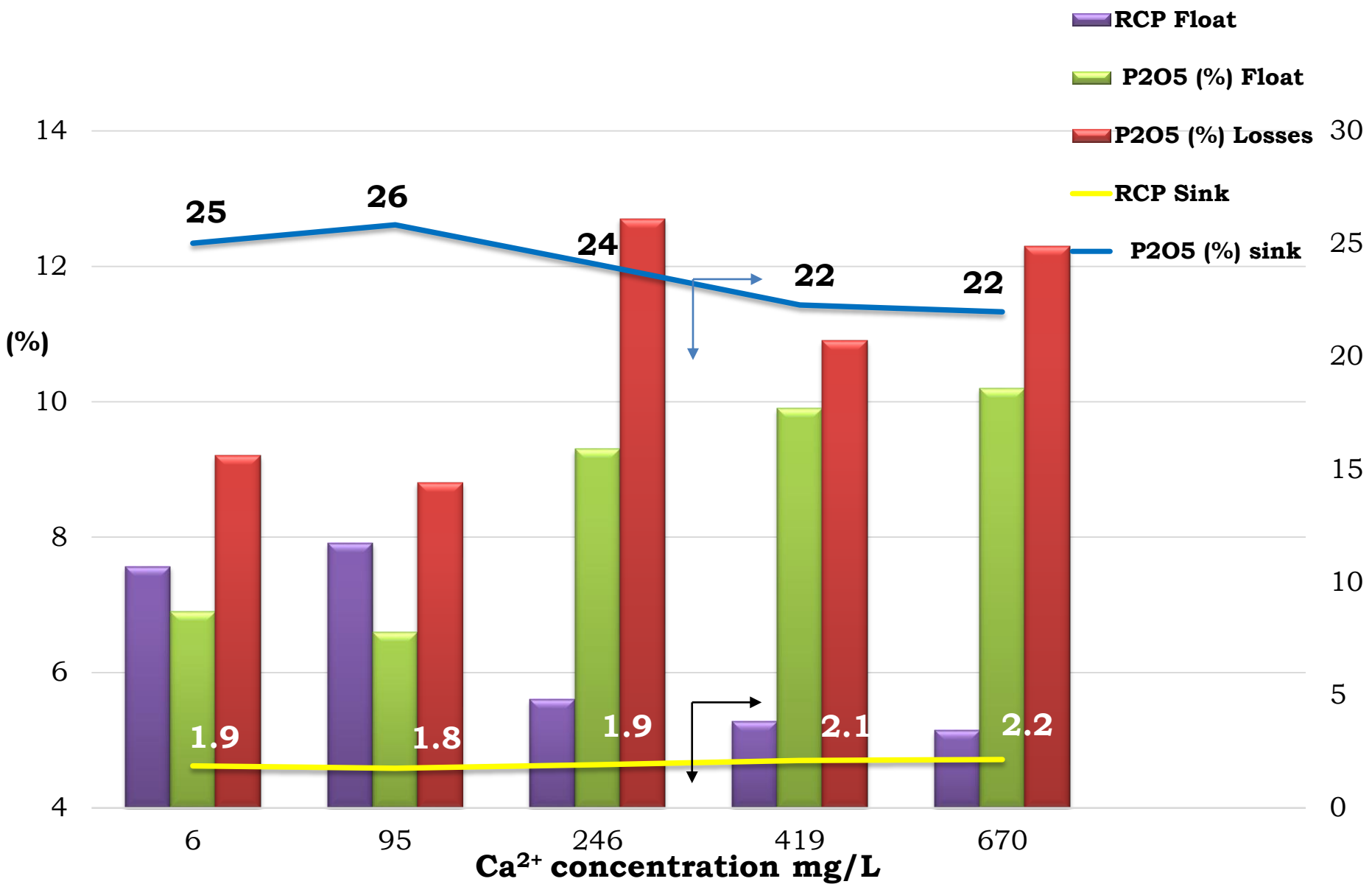
Residual water/Water collected

Atomic Absorption Spectrometry
$Ca^{2+}$ ion concentration analyzed

**Standard test**
**$Ca^{2+}$ (8 mg/L)**

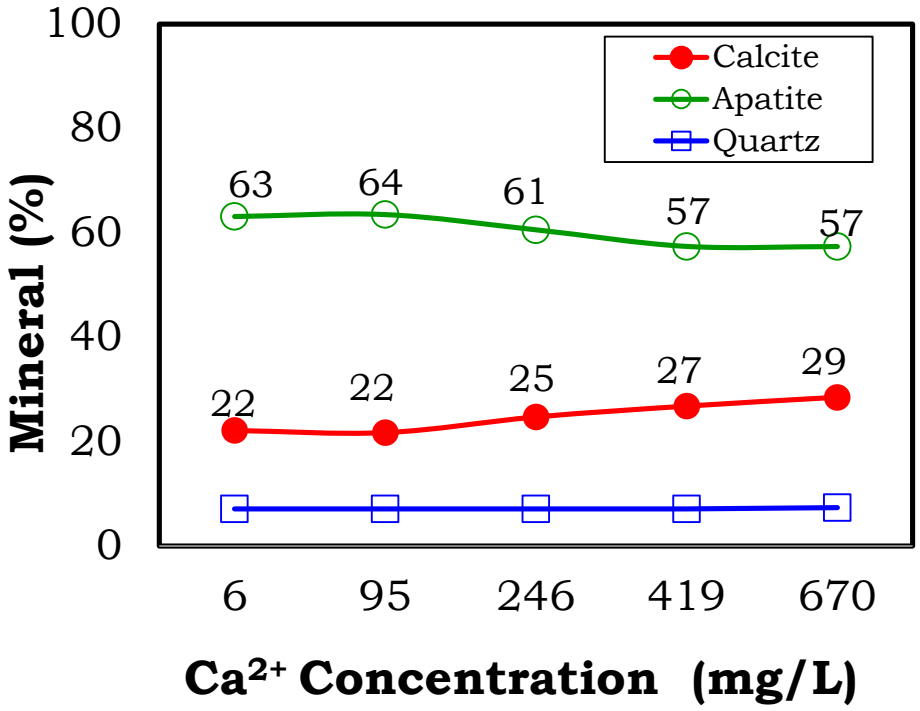
# RESULTS

# The effect of the $Ca^{2+}$ ions concentration on the $P_2O_5$ content, $P_2O_5$ losses and RCP from the products of the calcite flotation

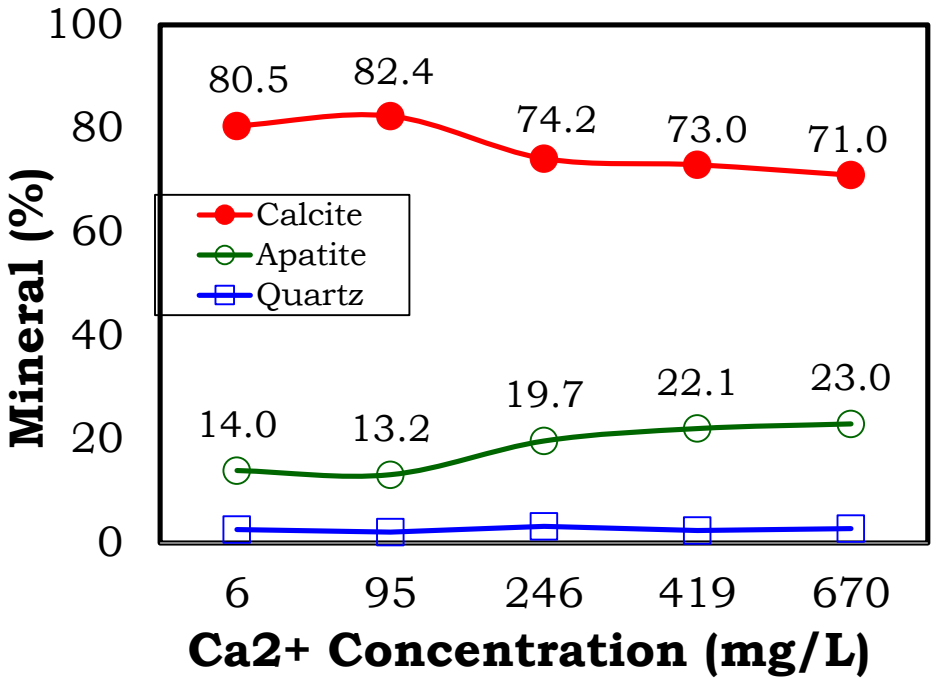


# Effect of ions $Ca^{2+}$ concentration on calcite, apatite and quartz minerals

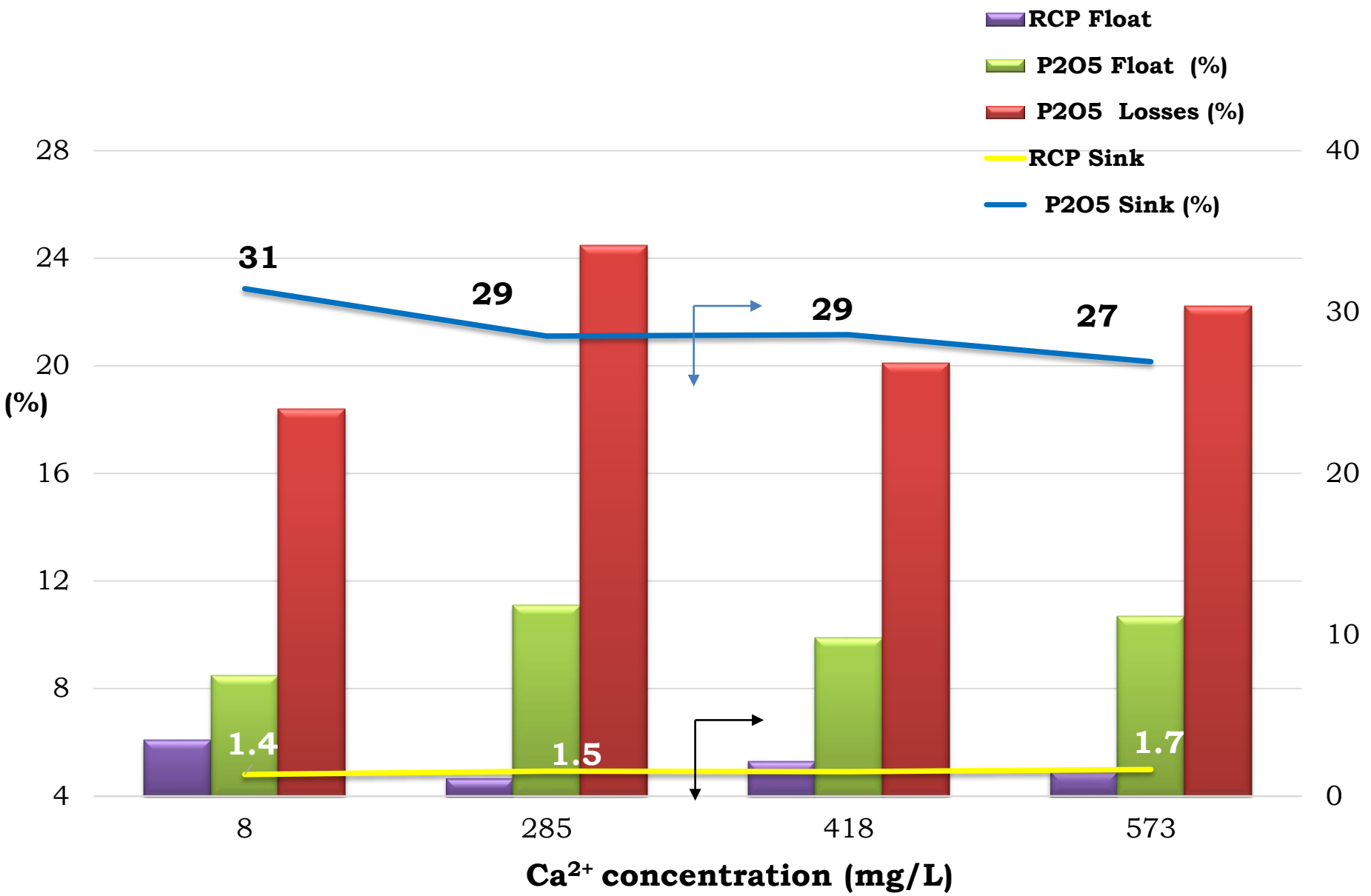
## Sink Fraction




## Float Fraction

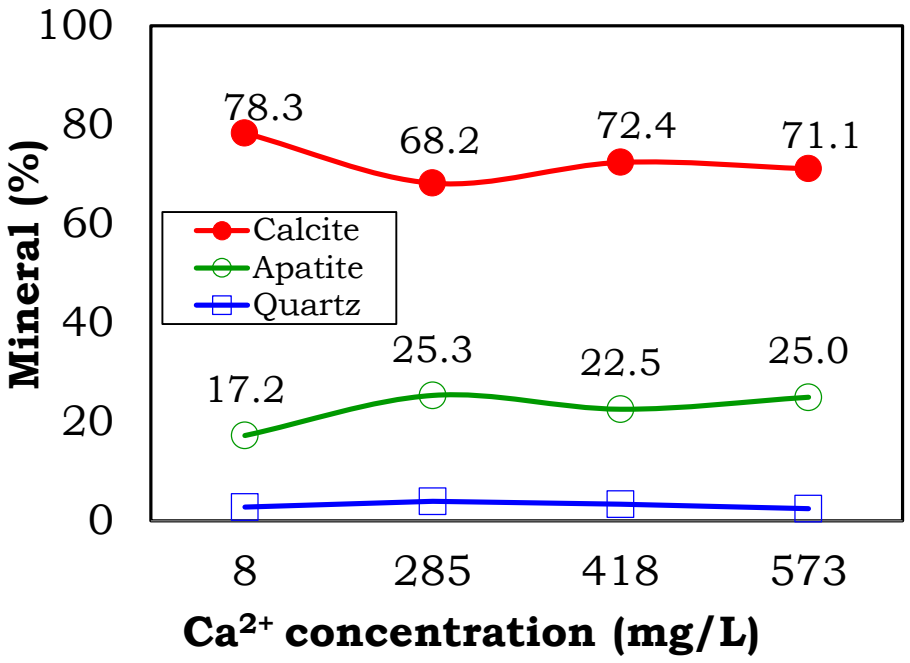


# Effect of recirculating process water on $P_2O_5$ content and losses and RCP

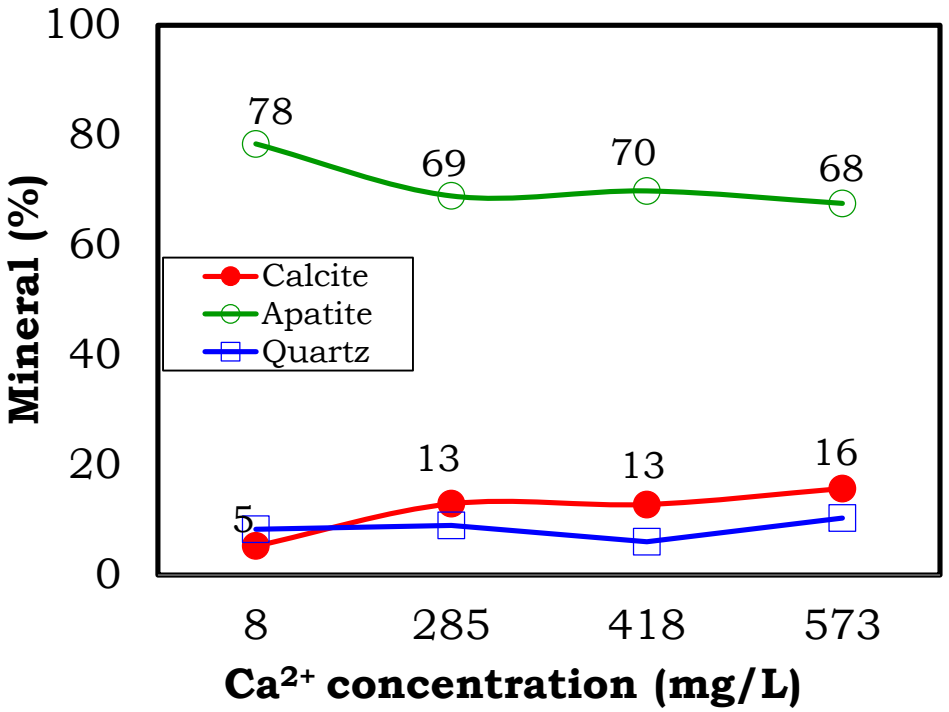


# Effect of ions $Ca^{2+}$ concentration in water recycled on calcite, apatite and quartz minerals

## Float Fraction




## Sink Fraction



# Final remarks

The results showed that $Ca^{2+}$ ions accumulation **reduces the performance of the calcite flotation** using carbonic gas, and fatty acid soap as a collector;

The reduction on the flotation performance was evidenced in the tests carried out with $Ca^{2+}$ concentrations increased from **6 mg/L to around 250 mg/L;**

- One of the alternatives to improve the concentrate quality (sink fraction) **could be adding one more flotation stage** of the sink fraction;

- Considering that the collector reacts with the calcium present in the calcite as well as with the free $Ca^{2+}$ ions, **the calcite flotation must be conducted with a higher collector dosage** in order to reach the same flotation performance of contamination-free phosphate rock.

# Final remark

Even though the accumulation of calcium ions **affects the quality of phosphate concentrate** (sink fraction) using carbonic gas, the process can be a technical alternative **that causes less impact in flotation performance** between carbonate minerals and apatite.

# Acknowledgments


CETEM
CENTRO DE TECNOLOGIA MINERAL

MINISTÉRIO DA
CIÊNCIA, TECNOLOGIA,
INOVAÇÕES E COMUNICAÇÕES

BRASIL
GOVERNO FEDERAL

CNPq
Conselho Nacional de Desenvolvimento
Científico e Tecnológico

UFRGS
UNIVERSIDADE FEDERAL
DO RIO GRANDE DO SUL

INB
INDÚSTRIAS NUCLEARES DO BRASIL

YARA
Knowledge grows

**Yara - Galvani**

**Dr. Reiner Neumann - CETEM**

**To all institutions that support research in Brazil**

**CETEM – Centre for Mineral Technology**

**Rio de Janeiro (Brazil)**

**www.cetem.gov.br**

**Amanda Soares de Freitas**

**Mining Engineering**

**amandasoaresfreitas@yahoo.com**